



## SECTION 1026

### REINFORCED CONCRETE CULVERT, STORM DRAIN AND SEWER PIPE

**1026.1 Scope.** These specifications cover reinforced concrete pipe to be used for the conveyance of sewage, industrial wastes and storm water and for the construction of culverts.

**1026.2 Classes.** Pipe manufactured according to these specifications shall be of five classes identified as Class I, Class II, Class III, Class IV and Class V. The corresponding strength requirements are specified in Tables I to V.

#### **1026.3 Basis of Acceptance.**

**1026.3.1** Unless otherwise specified in the contract, two separate and alternate bases of acceptance are permitted as follows:

**1026.3.1.1 Acceptance on Basis of Plant Load Bearing Tests, Material Tests and Inspection of the Manufactured Pipe for Visual Defects and Imperfections.** Acceptability of the pipe in all diameters and classes produced in accordance with [Sec 1026.9](#) or [1026.10](#) shall be determined by the results of the three-edge bearing tests for either the load to produce a 0.01-inch (0.3 mm) crack or at the option of the engineer, the load to produce a 0.01-inch (0.3 mm) crack and the ultimate strength of the pipe; by such material tests as are required in [Sec 1026.5](#), [1026.6](#) and [1026.7](#); by absorption tests on selected samples of concrete from the wall of the pipe; and by visual inspection of the finished pipe to determine conformance with the accepted design and freedom from defects.

**1026.3.1.2 Acceptance on Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.** Acceptability of the pipe in all diameters and classes shall be determined by the results of such material tests as are required in [Sec 1026.5](#), [1026.6](#) and [1026.7](#); by crushing tests on concrete cores or cured concrete cylinders; by absorption tests on selected samples from the wall of the pipe; and by inspection of the finished pipe, including quantity and placement of reinforcement, to determine conformance with the accepted design and freedom from defects.

**1026.3.1.3** The engineer may select and have applied the basis of acceptance in either [Sec 1026.3.1.1](#) or [1026.3.1.2](#).

**1026.3.2 Age for Acceptance.** Pipe will be considered ready for acceptance when the pipe conforms to the requirements, as indicated by the specified tests.

#### **Material**

**1026.4 Reinforced Concrete.** The reinforced concrete shall consist of a mixture of cement, mineral aggregates and water, in which steel has been embedded in such manner that the steel and the concrete act together.

**1026.5 Cement.** Cement shall conform to the requirements of [Sec 1019](#). Fly ash or GGBFS may be used to replace cement in accordance with [Sec 501](#).

**1026.6 Steel Reinforcement.** Reinforcement may consist (1) of wire conforming to AASHTO M 32 or AASHTO M 225, (2) of wire fabric conforming to AASHTO M 55 or AASHTO M 221, except the requirements for weld shear tests and the variation of diameter of transverse wires shall be waived or (3) of bars conforming to AASHTO M 31.

**1026.7 Aggregates.** Fine and coarse aggregates shall conform to the requirements of [Sec 1005](#), except that requirements for gradation and percent passing the No. 200 (75  $\mu\text{m}$ ) sieve shall not apply.

**1026.8 Mixture.** The aggregates shall be sized, graded, proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements. Admixtures or blends may be used with the approval of the engineer. In no case, however, shall the proportion of cement in the mixture be less than 564 pounds per cubic yard (335  $\text{kg}/\text{m}^3$ ) of concrete.

### **Design**

**1026.9 Design Tables.** The diameter, wall thickness, compressive strength of the concrete and the quantity of the circumferential reinforcement shall be as prescribed for Classes I to V in Tables I to V, subject to the provisions of [Sec 1026.10](#), [1026.11](#), [1026.21](#) and [1026.23](#).

**1026.10 Modified or Special Designs.** The manufacturer may request approval of modified designs which differ from the designs in [Sec 1026.9](#); or special designs for sizes and loads beyond those shown in Tables I to V; or special designs for pipe sizes that do not have steel reinforcement areas shown in Tables II to V.

**1026.10.1** Such modified or special designs shall be based on rational or empirical evaluations of the ultimate strength and cracking behavior of pipe and shall fully describe to the engineer any deviations from the requirements of [Sec 1026.9](#). The descriptions of modified or special designs shall include the wall thickness, the concrete strength and the area, type, placement, number of layers and strength of the steel reinforcement.

**1026.10.2** The manufacturer shall submit to the engineer proof of the adequacy of the proposed modified or special design. Such proof may comprise the submission of properly certified three-edge bearing tests already made, which are found by the engineer to be adequate or, if such three-edge bearing tests are not available or acceptable, the manufacturer may be required to perform proof tests on sizes and classes selected by the engineer to demonstrate the correctness and adequacy of the proposed design.

**1026.10.3** Such pipe shall meet all of the test and performance requirements specified by the engineer in accordance with [Sec 1026.3](#).

### **1026.11 Placing Reinforcement.**

**1026.11.1** Where one line of circular reinforcement is used, the reinforcement shall be placed from 35 to 50 percent of the wall thickness from the inner surface of the pipe except that for wall thicknesses less than 2 1/2 inches (63 mm), the protective cover of the concrete over the circumferential reinforcement in the wall of the pipe shall be 3/4 inch (19 mm). In circular pipe having two lines of circular reinforcement, each line shall be so placed that the protective covering of concrete over the circumferential reinforcement in the wall of the pipe shall be one inch (25 mm). In circular pipe having elliptical reinforcement with wall thickness 2 1/2 inches (63 mm) or over, the reinforcement in the wall of the pipe shall be so placed that the protective covering of concrete over the circumferential reinforcement along the vertical diameter of the

pipe shall be one inch (25 mm) from the inside surface of the pipe and the protective covering of concrete over the circumferential reinforcement along the horizontal diameter of the pipe shall be one inch (25 mm) from the outside surface of the pipe. In all pipe 36 inches (900 mm) or more in diameter, the bell or the spigot of the joint shall contain circumferential reinforcement. For double-cage pipe, reinforcement shall be at least equal in area to that of the outside cage or line for bells or the inside cage or line for spigots. For single-cage pipe, reinforcement shall be at least equal in area to that of the cage for either the bell or spigot. The location of the reinforcement shall be subject, to the permissible variations in dimensions given in [Sec 1026.23](#).

**1026.11.2** A line of circumferential reinforcement of any given total area may be composed of two layers for pipe with wall thickness of less than 7 inches (180 mm) or three layers for pipe with wall thicknesses of 7 inches (180 mm) or greater. The layers shall not be separated by more than the thickness of one longitudinal member plus 1/4 inch (6 mm). The multiple layers shall be tied together to form a single rigid cage. All other specification requirements such as laps, welds and tolerances of placement in the wall of the pipe shall apply to this method of fabricating a line of reinforcement.

**1026.12 Longitudinal Reinforcement.** Each line of circumferential reinforcement shall be assembled into a cage which shall contain sufficient longitudinal bars or members, extending through the wall of the pipe, to maintain the reinforcement rigidly in shape and in correct position within the form. The exposure of the ends of longitudinal members, stirrups or spacers that have been used to position the cages during the placement of the concrete shall not be a cause for rejection.

**1026.13 Laps, Welds and Spacing.** If the splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars and deformed cold worked wire and 40 diameters for plain bars and cold-drawn wire. In addition, where lapped cages of welded wire fabric are used without welding, the lap shall contain a longitudinal wire. If splices are welded and are not lapped to the minimum requirements above, pull tests of representative specimens shall develop at least 50 percent of the minimum specified strength of the steel and there shall be a minimum lap of 2 inches (50 mm). For butt-welded splices in bars or wire, pull tests of representative specimens shall develop at least 75 percent of the minimum specified strength of the steel. The spacing center to center of adjacent rings of circumferential reinforcement in a cage shall not exceed 4 inches (100 mm) for pipe up to and including pipe having a 4-inch (100 mm) wall thickness nor exceed the wall thickness for larger pipe and shall in no case exceed 6 inches (150 mm). The continuity of the circumferential reinforcing steel shall not be destroyed during the manufacture of the pipe.

**1026.14 Joints.** The joints shall be of such design and the ends of concrete pipe sections shall be so formed that when the sections are laid together they will make a continuous line of pipe with a smooth interior free from appreciable irregularities in the flowline compatible with the tolerances given in [Sec 1026.23.1](#). If specified, joints shall be Type A rubber gaskets conforming to the requirements of AASHTO M 198. The manufacturer shall make tests in accordance with Section 8 of AASHTO M 198 to demonstrate adequate performance and shall furnish a certification in triplicate that the physical and chemical properties of the gasket conform to the requirements of this specification.

## **Manufacture**

**1026.15 Placement of Concrete.** The transporting and placing of concrete shall be by methods that will prevent the segregation of the concrete material and the displacement of the reinforcement steel from its proper position in the form.

**1026.16 Curing.** Pipe shall be cured by any one of the following methods or by any other method or combination of methods approved by the engineer, that will give satisfactory results. The pipe shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.

**1026.16.1 Steam Curing.** Pipe may be placed in a curing chamber, free from outside drafts and cured in a moist atmosphere maintained by the injection of steam for such time and at such temperature as may be needed to enable the pipe to meet the strength requirements. The curing chamber shall be so constructed as to allow full circulation of steam around the entire pipe.

**1026.16.2 Water Curing.** Concrete pipe may be water-cured by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose or by any other approved method that will keep the pipe moist during the specified curing period.

**1026.16.3** The manufacturer has the option to combine the methods described in [Sec 1026.16.1](#) and [1026.16.2](#) as long as the required concrete compressive strength is attained.

**1026.16.4 Curing Membrane.** A curing membrane conforming to the requirements of [Sec 1055](#) may be applied and shall be left intact until the strength requirements are met. The concrete at the time of application shall be within 10 degrees F (6 C) of the atmospheric temperature. All surfaces shall be kept moist prior to the application of the compound and shall be damp when the compound is applied.

**1026.17 Lift Holes.** If agreed upon by the engineer and the manufacturer, not more than two holes may be cast or drilled in the wall of each piece of pipe for the purpose of handling at the construction site. The holes shall not be larger than 2 1/2 inches (63 mm) in diameter and shall be carefully cast or drilled in a manner so that it is not necessary to cut, bend or otherwise weaken the circumferential steel in the inner cage in pipe having two lines of reinforcement or any of the circumferential steel in pipe having one line of reinforcement. Lift holes will be permitted for rubber gasketed pipe only with the written approval of the engineer.

### **Physical Test Requirements**

**1026.18 Test Specimens.** The specified number of pipe required for tests shall be furnished without charge by the manufacturer, selected at random by the engineer and shall be pipe that would not otherwise be rejected under these specifications. The selection will be made at the point or points designated by the engineer.

### **1026.19 Number and Type of Tests Required for Various Delivery Schedules.**

**1026.19.1 Preliminary Test for Extended Delivery Schedules.** When it is required to make shipments at intervals over extended periods of time, the engineer will make such tests, preliminary to delivery of pipe, as are required by the type of basis of acceptance specified in [Sec 1026.3](#), of not more than three sections of pipe covering each size.

**1026.19.2 Additional Tests for Extended Delivery Schedules.** After the preliminary tests specified in [Sec 1026.19.1](#), the engineer will make additional tests as considered necessary, provided that the total number of pipe tested, including preliminary tests, shall not exceed one percent of the pipe delivered.

**1026.19.3 Tests for Occasional Orders.** For occasional orders, the engineer will, as considered necessary, test a number of pipe not to exceed 2 percent of an order and not to exceed five pieces of any one size.

#### **1026.20 External Load Crushing Strength Test Requirements.**

**1026.20.1** The load to produce a 0.01-inch (0.3 mm) crack or the ultimate load, as determined by the three-edge bearing method described in AASHTO T 280, shall be not less than that specified in Tables I to V for each respective class of pipe. Pipe that have been tested only to the formation of a 0.01-inch (0.3 mm) crack and that meet the 0.01-inch (0.3 mm) test load requirements will be accepted for use.

**1026.20.2 Retests of Pipe Not Meeting the External Load Crushing Strength Test Requirements.** Pipe will be considered as meeting the strength test requirements when all test specimens conform to the test requirements. Should any of the test specimens fail to meet the test requirements, the manufacturer will be allowed a retest on two additional specimens for each specimen that failed and the pipe will be acceptable only if all of the retest specimens meet the strength requirements.

#### **1026.21 Concrete Test Requirements.**

**1026.21.1 Compression Tests.** Compression tests for satisfying the design concrete strength may be made on either standard rodded concrete cylinders or cylinders compacted and cured in like manner as the pipe or on cores drilled from the wall of the pipe. If cylinders are tested, they shall be tested in accordance with AASHTO T 22. The average compressive strength of all cylinders tested shall be equal to or greater than the design strength. If cores are cut from the wall of the pipe and tested, they shall be cut and tested in accordance with AASHTO T 280. The compressive strength of each core tested shall be equal to or greater than the design strength of the concrete. If a core does not meet the required strength, another core from the same pipe may be tested. If this core does not meet the required strength, that pipe will be rejected. Additional tests shall be made on other pipe to determine the acceptability of the lot. If the cores cut from a section of pipe meet the strength test requirement, the core-holes shall be plugged and sealed by the manufacturer in a manner such that the pipe section will meet all of the test requirements of these specifications. Pipe sections so sealed shall be considered as satisfactory for use.

**1026.21.2 Absorption Test Requirements of Concrete.** The absorption of a sample from the wall of the pipe, as determined in accordance with AASHTO T 280, shall not exceed 9 percent of the dry weight (mass). Each sample shall be a piece broken from the wall or a core drilled from the wall, have a minimum area of 9 square inches (580 mm<sup>2</sup>) as measured on one surface of the wall, have a thickness equal to the wall and be free of visible cracks. If the initial absorption specimen from a pipe fails to conform to these specifications, an absorption test shall be made on another specimen from the same pipe and the results of the retest shall be substituted for the original test results.

**1026.21.3 Retest of Pipe Not Meeting the Concrete Test Requirements.** If not more than 20 percent of the concrete test specimens fail to pass the requirements of the specification, the manufacturer may cull stock and may eliminate whatever quantity of pipe desired and shall so mark those pipe that they will not be shipped. The required tests shall be made on the remainder of the order and the pipe will be accepted if they conform to the test requirements.

**1026.22 Test Equipment.** Each manufacturer furnishing pipe under these specifications shall furnish all facilities and personnel necessary to carry out the tests described in AASHTO T 280.

#### **1026.23 Permissible Variations in Dimensions.**

**1026.23.1** Permissible variations in internal diameter are as shown in Table VI. The wall thickness shall not be less than that shown in the design by more than 5 percent or 3/16 inch (5 mm), whichever is greater. A wall thickness more than that required in the design shall not be a cause for rejection. Pipe having localized variations in wall thickness exceeding those specified above will be accepted if the three-edge bearing strength and minimum steel cover requirements are met.

**1026.23.2 Permissible Variations in the Position of the Reinforcement.** The maximum variation in the position of the reinforcement shall be 10 percent of the wall thickness or 1/2 inch (13 mm), whichever is greater. Pipe having variations in the position of the reinforcement exceeding those specified above will be accepted if the three-edge bearing strength requirements obtained on a representative specimen are met. In no case, however, shall the cover over the reinforcement be less than 1/2 inch (13 mm). These tolerances or cover requirements do not apply to mating surfaces of the joint.

**1026.23.3** Reinforcement will be considered as meeting the design requirements if the area, computed on the basis of nominal area of the wire or bars used, equals or exceeds the requirements of [Sec 1026.9](#) or [1026.10](#). Actual area of the reinforcement used may vary from the nominal area according to permissible variations of the specifications for the reinforcement. If inner cage and outer cage reinforcement is used, the inner cage design area may vary to the lower limit of 85 percent of the elliptical design area and the outer cage design area may vary to the lower limit of 51 percent of the elliptical design area provided that the total design area of the inner cage plus the outer cage shall not vary beyond the lower limit of 140 percent of the elliptical design area.

**1026.23.4** Variations in the laying length of two opposite sides of pipe shall be not more than 1/4 inch for all sizes through 24-inch (600 mm) internal diameter and not more than 1/8 inch per foot (10 mm/m) of internal diameter for all sizes larger with a maximum of 5/8 inch (16 mm) in any length of pipe through 84-inch (2100 mm) internal diameter and a maximum of 3/4 inch (19 mm) for 90-inch (2250 mm) diameter or larger, except where beveled end pipe for laying on curves is specified.

**1026.23.5** The underrun in length of a section of pipe shall be not more than 1/8 inch per foot (10 mm/m) with a maximum of 1/2 inch (13 mm) in any length of pipe.

**1026.24 Finish.** Pipe shall be substantially free of fractures, large or deep cracks and surface roughness. The ends of the pipe shall be normal to the walls and centerline of the pipe, within the limits of variations given in [Sec 1026.23.4](#) and [1026.23.5](#).

**1026.25 Marking.** The following information shall be clearly marked on the inside of each section of pipe by indenting on the pipe section or by painting thereon with waterproof paint:

- (a) The pipe class and type of wall.
- (b) The date of manufacture.
- (c) The name or trade-mark of the manufacturer.

(d) One end of each section of pipe with elliptical reinforcement shall be clearly marked, during the process of manufacturing or immediately thereafter, on the inside and the outside of opposite walls along the minor axis of the elliptical reinforcement with the word "Top" or "Bottom" to designate the proper position when laid.

**1026.26 Inspection.** The quality of material, the process of manufacture and the finished pipe shall be subject to inspection and approval by the engineer.

**1026.27 Rejection.** Pipe shall be subject to rejection for failure to conform to any of the specification requirements. Individual sections of pipe may be rejected because of any of the following:

- (a) Fractures or cracks passing through the wall except for a single end crack that does not exceed the depth of the joint.

- (b) Defects that indicate imperfect proportioning, mixing or molding.

- (c) Surface defects indicating honeycombed or open texture.

- (d) Damaged or unsatisfactorily manufactured ends, if such would prevent making a satisfactory joint.

- (e) Any continuous crack having a surface width of 0.01 inch (0.3 mm) or more and extending for a length of 12 inches (300 mm) or more, regardless of position in the wall of the pipe.

**1026.28 Repairs.** Pipe may be repaired, if necessary, because of occasional imperfections in manufacture or accidental injury during handling and will be acceptable if, in the judgment of the engineer, the repairs are sound and properly finished and cured and the repaired pipe conforms to the requirements of these specifications.

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TABLE I									
Design Requirements for Class I Reinforced Concrete Pipe <sup>a</sup>									
ENGLISH									
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.									
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.									
D-Load to produce a 0.01-in. crack ..... 800									
D-Load to produce the ultimate load <sup>b</sup> ..... 1200									
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>i</sup>								
	Wall A				Wall B				
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	
		Inner Cage	Outer Cage			Inner Cage	Outer Cage		
60	5	0.25	0.15	0.28	6	0.21	0.13	0.23	
66	5 1/2	0.30	0.18	0.33	6 1/2	0.25	0.15	0.28	
72	6	0.35	0.21	0.39	7	0.29	0.17	0.32	
78	6 1/2	0.40	0.24	0.44	7 1/2	0.32	0.19	0.36	
84	7	0.45	0.27	0.50	8	0.37	0.22	0.41	
90	7 1/2	0.49	0.29	0.54	8 1/2	0.41	0.25	0.46	
96	8	0.54	0.32	0.60	9	0.46	0.28	0.51	
	Concrete Strength, 5000 psi								
102	8 1/2	0.63	0.38	Inner Circular 0.25 Plus Elliptical 0.38	9 1/2	0.54	0.32	Inner Circular 0.22 Plus Elliptical 0.32	
108	9	0.68	0.41	Inner Circular 0.27 Plus Elliptical 0.41	10	0.61	0.37	Inner Circular 0.24 Plus Elliptical 0.37	

METRIC									
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.									
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.									
D-Load to produce a 0.3-mm crack ..... 40.0									
D-Load to produce the ultimate load <sup>b</sup> ..... 60.0									
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> / linear m of pipe wall <sup>i</sup>								
	Wall A				Wall B				
	Concrete Strength, 27.6Pa				Concrete Strength, 27.6 MPa				
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	
		Inner Cage	Outer Cage			Inner Cage	Outer Cage		
1500	125	5.3	3.2	5.9	150	4.4	2.6	4.9	
1650	138	6.4	3.8	7.0	163	5.3	3.2	5.9	
1800	150	7.4	4.4	8.3	175	6.1	3.7	6.8	
1950	163	8.5	5.1	9.3	188	6.8	4.1	7.6	
2100	175	9.5	5.7	10.6	200	7.8	4.7	8.7	
2250	188	10.4	6.2	11.4	213	8.7	5.2	9.7	
2400	200	11.4	6.8	12.7	225	9.7	5.8	10.8	
	Concrete Strength, 34.5 MPa								
2250	213	13.3	8.0	Inner Circular 5.3 Plus Elliptical 8.0	238	11.4	6.8	Inner Circular 4.6 Plus Elliptical 6.8	
2700	225	14.4	8.6	Inner Circular 5.8 Plus Elliptical 8.6	250	12.9	7.7	Inner Circular 5.2 Plus Elliptical 7.7	

See footnotes under Table V.

TABLE II												
Design Requirements for Class II Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack .....										1000		
D-Load to produce the ultimate load <sup>b</sup> .....										1500		
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.07 <sup>e</sup>	....	....	2	0.07 <sup>e</sup>	....	....	2 3/4	0.07 <sup>e</sup>	....	....
15	1 7/8	0.07 <sup>e</sup>	....	....	2 1/4	0.07 <sup>e</sup>	....	....	3	0.07 <sup>e</sup>	....	....
18	2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	2 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
21	2 1/4	0.12	....	0.10	2 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
24	2 1/2	0.13	....	0.11	3	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
27	2 5/8	0.15	....	0.13	3 1/4	0.13	....	0.11	4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
30	2 3/4	0.15	....	0.14	3 1/2	0.14	....	0.12	4 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
33	2 7/8	0.16	....	0.15	3 3/4	0.15	....	0.13	4 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
36	3	0.14	0.08	0.15	4 <sup>g</sup>	0.12	0.07	0.13	4 3/4	0.07	0.07	0.08
42	3 1/2	0.16	0.10	0.18	4 1/2	0.15	0.09	0.17	5 1/4	0.10	0.07	0.11

48	4	0.21	0.13	0.23	5	0.18	0.11	0.20	5 3/4	0.14	0.08	0.15
54	4 1/2	0.25	0.15	0.28	5 1/2	0.22	0.13	0.24	6 1/4	0.17	0.10	0.19
60	5	0.30	0.18	0.33	6	0.25	0.15	0.28	6 3/4	0.22	0.13	0.24
66	5 1/2	0.35	0.21	0.39	6 1/2	0.31	0.19	0.34	7 1/4	0.25	0.15	0.28
72	6	0.41	0.25	0.45	7	0.35	0.21	0.39	7 3/4	0.30	0.18	0.33
78	6 1/2	0.46	0.28	0.51	7 1/2	0.40	0.24	0.44	8 1/4	0.35	0.21	0.39
84	7	0.51	0.31	0.57	8	0.46	0.28	0.51	8 3/4	0.41	0.25	0.46
90	7 1/2	0.57	0.34	0.63	8 1/2	0.51	0.31	0.57	9 1/4	0.48	0.29	0.53
96	8	0.62	0.37	0.69	9	0.57	0.34	0.63	9 3/4	0.55	0.33	0.61
	<b>Concrete Strength, 5000 psi</b>				<b>Concrete Strength, 5000 psi</b>				<b>Concrete Strength, 5000 psi</b>			
102	8 1/2	0.76	0.46	Inner Circular 0.30 Plus Elliptical0.46	9 1/2	0.68	0.41	Inner Circular 0.27 Plus Elliptical0.41	10 1/4	0.62	0.37	Inner Circular 0.25 Plus Elliptical 0.37
108	9	0.85	0.51	Inner Circular 0.34 Plus Elliptical0.51	10	0.76	0.46	Inner Circular 0.30 Plus Elliptical0.46	10 3/4	0.70	0.42	Inner Circular 0.28 Plus Elliptical 0.42

METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack ..... 50.0												
D-Load to produce the ultimate load <sup>B</sup> ..... 75.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	1.5 <sup>e</sup>	....	....	50	1.5 <sup>e</sup>	....	....	69	1.5 <sup>e</sup>	....	....
375	47	1.5 <sup>e</sup>	....	....	57	1.5 <sup>e</sup>	....	....	75	1.5 <sup>e</sup>	....	....
450	50	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	63	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	82	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
525	57	2.5	....	2.1	69	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	88	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
600	63	2.8	....	2.3	75	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	94	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
675	66	3.2	....	2.8	82	2.8	....	2.3	100	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
750	69	3.2	....	3.0	88	3.0	....	2.5	106	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
825	72	3.4	....	3.2	94	3.2	....	2.8	113	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
900	75	3.0	1.8	3.2	100 <sup>g</sup>	2.5	1.5	2.8	119 <sup>g</sup>	1.5	1.5	7.1
1050	88	3.4	2.0	3.8	113	3.2	1.9	3.6	132	2.1	1.5	2.3
1200	100	4.5	2.7	4.9	125	3.8	2.3	4.2	144	3	1.8	3.2
1350	113	5.3	3.2	5.9	138	4.7	2.8	5.1	157	3.6	2.2	4.0

1500	125	6.4	3.8	7.0	150	5.3	3.2	5.9	169	4.7	2.8	5.1
1650	138	7.4	4.4	8.3	163	6.6	4.0	7.2	182	5.3	3.2	5.9
1800	150	8.7	5.2	9.5	175	7.4	4.4	8.3	194	6.4	3.8	7.0
1950	163	9.7	5.8	10.8	188	8.5	5.1	9.3	207	7.4	4.4	8.3
2100	175	10.8	6.5	12.1	200	9.7	5.8	10.8	219	8.7	5.2	9.7
2250	188	12.1	7.3	13.3	213	10.8	6.5	12.1	232	10.2	6.1	11.2
2400	200	13.1	7.9	14.6	225	12.1	7.3	13.3	244	11.6	7.0	12.9
	<b>Concrete Strength, 34.5 MPa</b>				<b>Concrete Strength, 34.5 MPa</b>				<b>Concrete Strength, 34.5 MPa</b>			
2550	213	0.76	9.7	Inner Circular 6.4 Plus Elliptical 9.7	238	14.4	8.6	Inner Circular 5.8 Plus Elliptical 8.6	257	13.1	7.9	Inner Circular 5.2 Plus Elliptical 7.9
2700	225	0.85	10.8	Inner Circular 7.2 Plus Elliptical 10.8	250	16.1	9.7	Inner Circular 6.4 Plus Elliptical 9.7	269	14.8	8.9	Inner Circular 5.9 Plus Elliptical 8.9

See footnotes under Table V.

TABLE III												
Design Requirements for Class III Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 1350												
D-Load to produce the ultimate load <sup>b</sup> ..... 2000												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>f</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>	Wall Thick- ness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforce- ment <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.07 <sup>e</sup>	....	....	2	0.07 <sup>e</sup>	....	....	2 3/4	0.07 <sup>e</sup>	....	....
15	1 7/8	0.07 <sup>e</sup>	....	....	2 1/4	0.07 <sup>e</sup>	....	....	3	0.07 <sup>e</sup>	....	....
18	2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	2 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
21	2 1/4	0.14	....	0.11	2 3/4	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 1/2	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>
24	2 1/2	0.17	....	0.14	3	0.07 <sup>e</sup>	....	0.07 <sup>e</sup>	3 3/4	0.07	....	0.07 <sup>e</sup>
27	2 5/8	0.18	....	0.16	3 1/4	0.16	....	0.14	4	0.08	....	0.07 <sup>e</sup>
30	2 3/4	0.19	....	0.18	3 1/2	0.18	....	0.15	4 1/4	0.10	....	0.08
33	2 7/8	0.21	....	0.20	3 3/4	0.20	....	0.17	4 1/2	0.12	....	0.10
36	3	0.21	0.13	0.23	4	0.17	0.10	0.19	4 3/4 <sup>b</sup>	0.08	0.07	0.09
42	3 1/2	0.25	0.15	0.28	4 1/2	0.21	0.13	0.23	5 1/4	0.12	0.07	0.13

48	4	0.32	0.19	0.35	5	0.24	0.14	0.27	5 3/4	0.16	0.10	0.18
54	4 1/2	0.38	0.23	0.42	5 1/2	0.29	0.17	0.32	6 1/4	0.21	0.13	0.23
60	5	0.44	0.26	0.49	6	0.34	0.20	0.38	6 3/4	0.25	0.15	0.28
66	5 1/2	0.50	0.30	0.55	6 1/2	0.41	0.25	0.46	7 1/4	0.31	0.19	0.34
72	6	0.57	0.34	0.63	7	0.49	0.29	0.54	7 3/4	0.36	0.22	0.40
	Concrete Strength, 5000 psi											
78	6 1/2	0.64	0.38	0.71	7 1/2	0.57	0.34	0.63	8 1/4	0.42	0.25	0.47
84	7	0.72	0.43	0.80	8	0.64	0.38	0.71	8 3/4	0.50	0.30	0.56
					Concrete Strength, 5000 psi				Concrete Strength, 5000 psi			
90	7 1/2	0.81	0.49	0.90	8 1/2	0.69	0.41	0.77	9 1/4	0.59	0.35	0.66
96	8	0.93	0.56	1.03	9	0.76	0.46	0.84	9 3/4	0.70	0.42	Inner Circular 0.28 Plus Elliptical 0.42
102	8 1/2	1.03	0.62	Inner Circular 0.41 Plus Elliptical 0.62	9 1/2	0.90	0.54	Inner Circular 0.36 Plus Elliptical 0.54	10 1/4	0.83	0.50	Inner Circular 0.33 Plus Elliptical 0.50
108	9	1.22	0.73	Inner Circular 0.49 Plus Elliptical 0.73	10	1.08	0.65	Inner Circular 0.43 Plus Elliptical 0.65	10 3/4	0.99	0.59	Inner Circular 0.40 Plus Elliptical 0.59



METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack .....65.0												
D-Load to produce the ultimate load <sup>b</sup> .....100.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /per linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa				Concrete Strength, 27.6 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	1.5 <sup>e</sup>	....	....	50	1.5 <sup>e</sup>	....	....	69	1.5 <sup>e</sup>	....	....
375	47	1.5 <sup>e</sup>	....	....	57	1.5 <sup>e</sup>	....	....	75	1.5 <sup>e</sup>	....	....
450	50	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	63	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	82	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
525	57	3.0	....	2.3	69	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	88	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>
600	63	3.6	....	3.0	75	1.5 <sup>e</sup>	....	1.5 <sup>e</sup>	94	1.5	....	1.5 <sup>e</sup>
675	66	3.8	....	3.4	82	3.4	....	3.0	100	1.7	....	1.5 <sup>e</sup>
750	69	4.0	....	3.8	88	3.8	....	3.2	107	2.1	....	1.7
825	72	4.4	....	4.2	94	4.2	....	3.6	113	2.5	....	2.1
900	75	4.4	2.6	4.7	100 <sup>h</sup>	3.6	2.2	4.0	119 <sup>h</sup>	1.7	1.5	1.9
1050	88	5.3	3.2	5.9	113	4.4	2.6	4.9	132	2.5	1.5	2.8
1200	100	6.8	4.1	7.4	125	5.1	3.1	5.7	144	3.4	2.0	3.8
1350	113	8.0	4.8	8.9	138	6.1	3.7	6.8	157	4.4	2.6	4.9

1500	125	9.3	5.6	10.4	150	7.2	4.3	8.0	169	5.3	3.2	5.9
1650	138	10.6	6.4	11.6	163	9.1	5.5	9.7	182	6.6	4.0	7.2
1800	150	12.1	7.3	13.3	175	10.4	6.2	11.4	194	7.6	4.6	8.5
	Concrete Strength, 34.5 MPa											
1950	163	13.5	8.1	15.0	188	12.1	7.3	13.3	207	8.9	5.3	9.9
2100	175	15.2	9.1	16.9	200	13.5	8.1	15.0	219	10.6	6.4	11.9
					Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa			
2250	188	17.1	10.3	19.1	213	14.6	8.8	16.3	232	12.5	7.2	14.0
2400	200	19.7	11.8	21.8	225	16.1	9.7	17.8	244	14.8	8.9	Inner Circular 5.9 Plus Elliptical 8.9
2550	213	21.8	13.1	Inner Circular 8.7 Plus Elliptical 13.1	238	19.1	11.5	Inner Circular 7.6 Plus Elliptical 11.5	257	17.6	10.6	Inner Circular 7.0 Plus Elliptical 10.6
2700	225	25.8	15.5	Inner Circular 10.3 Plus Elliptical 15.5	250	22.9	13.7	Inner Circular 9.2 Plus Elliptical 13.7	269	21.0	12.6	Inner Circular 8.4 Plus Elliptical 12.6

See Footnotes under Table V.

TABLE IV												
Design Requirements for Class IV Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 2000												
D-Load to produce the ultimate load <sup>b</sup> ..... 3000												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>1</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 5000 psi				Concrete Strength, 5000 psi				Concrete Strength, 5000 psi			
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	1 3/4	0.15	....	....	2	0.07	....	....	2 3/4	0.07 <sup>1</sup>	....	....
15	1 7/8	0.16	....	....	2 1/4	0.10	....	....	3	0.07 <sup>1</sup>	....	....
18	2	0.17	....	0.15	2 1/2	0.14	....	0.11	3 1/4	0.07 <sup>1</sup>	....	0.07 <sup>1</sup>
21	2 1/4	0.23	....	0.21	2 3/4	0.20	....	0.17	3 1/2	0.07 <sup>1</sup>	....	0.07 <sup>1</sup>
24	2 1/2	0.29	....	0.27	3	0.27	....	0.23	3 3/4	0.07	0.07	0.08
27	2 5/8	0.33	....	0.31	3 1/4	0.31	....	0.25	4	0.08	0.07	0.09
30	2 3/4	0.38	....	0.35	3 1/2	0.35	....	0.28	4 1/4	0.09	0.07	0.10
33	<sup>a</sup>	....	....	....	3 3/4	0.27	0.16	0.30	4 1/2	0.11	0.07	0.12
36	<sup>a</sup>	....	....	...	4	0.30	0.18	0.33	4 3/4	0.14	0.08	0.15

42	a	....	....	....	4 1/2	0.35	0.21	0.39	5 1/4	0.20	0.12	0.22
48	a	....	....	....	5	0.42	0.25	0.47	5 3/4	0.26	0.16	0.29
54	a	....	....	....	5 1/2	0.50	0.30	0.55	6 1/4	0.34	0.20	0.38
60	a	....	....	....	Concrete Strength, 5000 psi				6 3/4	0.41	0.25	0.46
					6	0.59	0.35	0.66				
66	a	....	....	....	6 1/2	0.69	0.41	0.77	7 1/4	0.51	0.31	0.57
									Concrete Strength, 5000 psi			
72	a	....	....	....	7	0.79	0.47	0.88	7 3/4	0.61	0.37	0.68
78	a	....	....	....	a	....	....	....	8 1/4	0.71	0.43	0.79
84	a	....	....	....	a	....	....	....	8 3/4	0.85	0.51	0.94
90	a	....	....	....	a	....	....	....	a	....	....	....
96	a	....	....	....	a	....	....	....	a	....	....	....
102	a	....	....	....	a	....	....	....	a	....	....	....
108	a	....	....	....	a	....	....	....	a	....	....	....

METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack ..... 100.0												
D-Load to produce the ultimate load <sup>b</sup> ..... 150.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa				Concrete Strength, 34.5 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	44	0.15	....	....	50	1.5	....	....	69	1.5 <sup>i</sup>	....	....
375	47	0.16	....	....	57	2.1	....	....	75	1.5 <sup>i</sup>	....	....
450	50	0.17	....	3.2	63	3.0	....	2.3	82	1.5 <sup>i</sup>	....	1.5 <sup>i</sup>
525	57	0.23	....	4.4	69	4.2	....	3.6	88	1.5 <sup>i</sup>	....	1.5 <sup>i</sup>
600	63	0.29	....	5.7	75	5.7	....	4.9	94	1.5	1.5	1.7
675	66	0.33	....	6.6	82	6.3	....	5.3	100	1.7	1.5	1.9
750	69	0.38	....	7.4	88	7.4	....	5.9	107	1.9	1.5	2.1
825	<sup>a</sup>	....	....	....	94	5.7	3.4	6.3	113	2.3	1.5	2.5
900	<sup>a</sup>	....	....	....	100	6.3	3.8	7.0	119	3.0	1.8	3.2
1050	<sup>a</sup>	....	....	....	113	7.4	4.4	8.3	132	4.2	2.5	4.7

1200	a	....	....	....	125	8.9	5.3	9.9	144	5.5	3.3	6.1
1350	a	....	....	....	138	10.6	6.4	11.6	157	7.2	4.3	8
1500	a	....	....	....	<b>Concrete Strength, 34.5 MPa</b>				169	8.7	5.2	9.7
					150	12.5	7.5	14.0				
1650	a	....	....	....	163	14.6	8.8	16.3	182	10.8	6.5	12.1
									<b>Concrete Strength, 34.5 MPa</b>			
1800	a	....	....	....	175	16.7	10.0	18.6	194	12.9	7.7	14.4
1950	a	....	....	....	A	....	....	....	207	15.0	9.0	16.7
2100	a	....	....	....	A	....	....	....	219	18.0	10.8	19.9
2250	a	....	....	....	A	....	....	....	a	....	....	....
2400	a	....	....	....	A	....	....	....	a	....	....	....
2550	a	....	....	....	A	....	....	....	a	....	....	....
2700	a	....	....	....	A	....	....	....	a	....	....	....

See Footnotes under Table V.

TABLE V												
Design Requirements for Class V Reinforced Concrete Pipe <sup>a</sup>												
ENGLISH												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.												
D-Load to produce a 0.01-in. crack ..... 3000												
D-Load to produce the ultimate load <sup>b</sup> ..... 3750												
Internal Diameter of Pipe, in.	Reinforcement, sq. in. per linear foot of pipe wall <sup>1</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 6000 psi				Concrete Strength, 6000 psi				Concrete Strength, 6000 psi			
	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, in.	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
12	<sup>a</sup>	....	....	....	2	0.10	....	....	2 3/4	0.07 <sup>1</sup>	....	....
15	<sup>a</sup>	....	....	....	2 1/4	0.14	....	....	3	0.07 <sup>1</sup>	....	....
18	<sup>a</sup>	....	....	....	2 1/2	0.19	....	0.16	3 1/4	0.10	....	....
21	<sup>a</sup>	....	....	....	2 3/4	0.24	....	0.21	3 1/2	0.10	....	....
24	<sup>a</sup>	....	....	....	3	0.30	....	0.24	3 3/4	0.12	0.07	0.13
27	<sup>a</sup>	....	....	....	3 1/4	0.38	0.23	0.42	4	0.14	0.08	0.16
30	<sup>a</sup>	....	....	....	3 1/2	0.41	0.25	0.46	4 1/4	0.18	0.11	0.20
33	<sup>a</sup>	....	....	....	3 3/4	0.46	0.28	0.51	4 1/2	0.23	0.14	0.25
36	<sup>a</sup>	....	....	....	4	0.50	0.30	0.56	4 3/4	0.27	0.16	0.30

42	a	....	....	....	4 1/2	0.60	0.36	0.67	5 1/4	0.36	0.22	0.40
48	a	....	....	....	5	0.73	0.44	0.81	5 3/4	0.47	0.28	0.52
54	a	....	....	....	a	....	....	....	6 1/4	0.58	0.35	0.64
60	a	....	....	....	a	....	....	....	6 3/4	0.70	0.42	0.78
66	a	....	....	....	a	....	....	....	7 1/4	0.74	0.50	0.93
72	a	....	....	....	a	....	....	....	7 3/4	0.99	0.59	1.10
78	a	....	....	....	a	....	....	....	a	....	....	....
84	a	....	....	....	a	....	....	....	a	....	....	....
90	a	....	....	....	a	....	....	....	a	....	....	....
96	a	....	....	....	a	....	....	....	a	....	....	....
102	a	....	....	....	a	....	....	....	a	....	....	....
108	a	....	....	....	a	....	....	....	a	....	....	....



METRIC												
NOTE: See <a href="#">Sec 1026.3</a> for basis of acceptance specified by the engineer.												
The strength test requirements in newtons per linear meter of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in newtons per linear meter per millimeter of diameter) to produce a 0.3-mm crack, or the D-loads to produce the 0.3-mm crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in millimeters.												
D-Load to produce a 0.3-mm crack ..... 140.0												
D-Load to produce the ultimate load <sup>b</sup> ..... 175.0												
Internal Diameter of Pipe, mm	Reinforcement, cm <sup>2</sup> /linear m of pipe wall <sup>i</sup>											
	Wall A				Wall B				Wall C			
	Concrete Strength, 41.4 MPa				Concrete Strength, 41.4 MPa				Concrete Strength, 41.4 MPa			
	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>	Wall Thickness, mm	Circular Reinforcement <sup>c</sup>		Elliptical Reinforcement <sup>d</sup>
		Inner Cage	Outer Cage			Inner Cage	Outer Cage			Inner Cage	Outer Cage	
300	a	....	....	....	50	2.1	....	....	69	1.5 <sup>i</sup>	....	....
375	a	....	....	....	57	3.0	....	....	75	1.5 <sup>i</sup>	....	....
450	a	....	....	....	63	4.0	....	3.4	82	2.1	....	....
525	a	....	....	....	69	5.1	....	4.4	88	2.1	....	....
600	a	....	....	....	75	6.4	....	5.1	94	2.5	1.5	2.8
675	a	....	....	....	82	8.0	4.8	8.9	100	3.0	1.8	3.4
750	a	....	....	....	88	8.7	5.2	9.7	107	3.8	2.3	4.2
825	a	....	....	....	94	9.7	5.8	10.8	113	4.9	2.9	5.3
900	a	....	....	....	100	10.6	6.4	11.9	119	5.7	3.4	6.3
1050	a	....	....	....	113	12.7	7.6	14.2	132	7.6	4.6	8.5
1200	a	....	....	....	125	15.5	9.3	17.1	144	9.9	5.9	11

1350	a	....	....	....	a	....	....	....	157	12.3	7.4	13.5
1500	a	....	....	....	a	....	....	....	169	14.8	8.9	16.5
1650	a	....	....	....	a	....	....	....	182	17.8	10.7	19.7
1800	a	....	....	....	a	....	....	....	194	21.0	12.6	23.3
1950	a	....	....	....	a	....	....	....	a	....	....	....
2100	a	....	....	....	a	....	....	....	a	....	....	....
2250	a	....	....	....	a	....	....	....	a	....	....	....
2400	a	....	....	....	a	....	....	....	a	....	....	....
2550	a	....	....	....	a	....	....	....	a	....	....	....
2700	a	....	....	....	a	....	....	....	a	....	....	....

- <sup>a</sup> For modified or special designs, see [Sec 1026.10](#) or with the permission of the engineer utilize the provisions for AASHTO M 242. Steel areas may interpolated between those shown for variations in diameter, loading or wall thickness. Pipe over 96 inches (2400 mm) in diameter shall have two circular cages or an inner circular plus one elliptical cage.
- <sup>b</sup> Three-edge-bearing test to ultimate load is not required for any class of pipe 60 inches (1500 mm) or less in diameter provided all other requirements of this specification are met.
- <sup>c</sup> As an alternate to design requiring both inner and outer circular cages, the reinforcement may be positioned and proportioned in either of the following manners:
- An inner circular cage plus an elliptical cage such that the area shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table.
  - An inner and outer cage plus quadrant mats in accordance with Figure 1 of AASHTO M 170, or
  - An inner and outer cage plus an elliptical cage in accordance with Figure 2 of AASHTO M 170.
- <sup>d</sup> Elliptical and quadrant steel must be held in place by means of holding rods, chairs or other positive means throughout the entire casting operation.
- <sup>e</sup> For these classes and sizes, the minimum practical steel reinforcement is specified. The actual ultimate strength is greater than the minimum strength specified for non reinforced pipe of equivalent diameters in AASHTO M 86.
- <sup>f</sup> For these classes and sizes, the minimum practical steel reinforcement is specified.
- <sup>g</sup> As an alternative, single cage reinforcement may be used. The reinforcement area is square inches per linear foot (square centimeters per linear meter) shall be 0.20 (4.2) for wall B and 0.16 (3.4) for wall C.
- <sup>h</sup> As an alternative, single cage reinforcement may be used. The reinforcement area is square inches per linear foot (square centimeters per linear meter) shall be .30 (6.4) for wall B and 0.20 (4.2) for wall C.
- <sup>i</sup> Reinforcement of pipe wall may be either that specified under Circular Reinforcement or as specified under Elliptical Reinforcement.

<b>TABLE VI</b>		
<b>Permissible Variations in Internal Diameter</b>		
<b>Diameter of Pipe, Inches (mm)</b>	<b>Min., Inches (mm)</b>	<b>Max., Inches (mm)</b>
12 (300)	11.875 (300)	12.125 (310)
15 (375)	14.75 (375)	15.25 (390)
18 (450)	17.75 (450)	18.25 (465)
21 (525)	20.625 (525)	21.375 (545)
24 (600)	23.625 (600)	24.375 (620)
27 (675)	26.625 (675)	27.375 (695)
30 (750)	29.625 (750)	30.375 (775)
33 (825)	32.625 (825)	33.375 (850)
36 (900)	35.625 (900)	36.375 (925)
42 (1050)	41.625 (1050)	42.375 (1080)
48 (1200)	47.5 (1200)	48.5 (1230)
54 (1350)	53.5 (1350)	54.5 (1385)
60 (1500)	59.375 (1500)	60.625 (1540)
66 (1650)	65.375 (1650)	66.625 (1695)
72 (1800)	71.25 (1800)	72.75 (1850)
78 (1950)	77.25 (1950)	78.75 (2000)
84 (2100)	83.125 (2100)	84.875 (2155)
90 (2250)	89.125 (2250)	90.875 (2310)
96 (2400)	95.0 (2400)	97.0 (2465)
102 (2550)	101.0 (2550)	103.0 (2620)
108 (2700)	106.875 (2700)	109.125 (2770)
114 (2850)	112.875 (2850)	115.125 (2925)
120 (3000)	118.75 (3000)	121.25 (3080)
126 (3150)	124.75 (3150)	127.25 (3235)
132 (3300)	130.625 (3300)	133.375 (3390)
138 (3400)	136.625 (3450)	139.375 (3540)
144 (3600)	142.5 (3600)	145.5 (3695)